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Effectiveness of Anaerobic Aerobic Biofilter System in Reducing BOD, COD, Ammonia, and Phosphate in PKU Muhammadiyah Hospital Surabaya in 2024

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ABSTRACT
The wastewater from PKU Muhammadiyah Hospital Surabaya that has been treated still contains phosphate and ammonia that do not meet the quality stand-ards of the Governor of East Java Regulation Number 72 of 2013. High levels of phosphate and ammonia should not be discharged directly into water bodies be-cause they can cause various environmental problems. The purpose of this study was to determine the effectiveness of the anaerobic aerobic biofilter system of the wastewater treatment plant in reducing BOD, COD, ammonia, and phosphate at PKU Muhammadiyah Hospital Surabaya. This study was designed using a de-scriptive research method. The research variables were the anaerobic aerobic bio-filter system of the wastewater treatment plant at PKU Muhammadiyah Hospital Surabaya by observing the decrease in BOD, COD, ammonia, and phosphate levels. The laboratory results of BOD, COD, ammonia, and phosphate levels were analyzed descriptively, referring to the Governor of East Java Regulation Number 72 of 2013 concerning Wastewater Quality Standards for Industry and/or Other Business Activities. Based on the results of laboratory test analysis, it shows that the wastewater treatment plant has been effective in reducing BOD (65.51%) and COD (70.65%), but is less effective in reducing ammonia and phosphate (28.66%). The quality of wastewater discharge from PKU Muham-madiyah Hospital Surabaya still exceeds the quality standards for the ammonia parameter, which is 0.144 mg/L, and the phosphate of 3.917 mg/L in accordance with the Regulation of the Governor of East Java Number 72 of 2013. Sugges-tions for the hospital are to monitor and evaluate the Anaerobic Aerobic Biofilter. Identify effective bacteria for seeding in the equalization tank so that the outlet discharge is in accordance with the quality standards.

Keywords: Effectiveness, Anaerobic-Aerobic Wastewater Treatment Plant

INTRODUCTION
Please note that the first paragraph of a section or subsection is not indented. The first paragraphs that follows a table, figure, equation etc. does not have an indent, either.

Subsequent paragraphs, however, are indented. Hospitals are health service facilities established as a form of effort to maintain and improve public health. Hospitals provide health services ranging from the emergency room to inpatient, outpatient, and emergency [1]. Hospitals carry out their operational functions, but hospitals also produce wastewater. Hospital wastewater is waste generated through hospital operational activities that contains many pathogenic microorganisms that are infectious, toxic chemicals, and can also be radioactive [2].

Hospital wastewater has the potential to reduce environmental quality. Wastewater from medical and non-medical activities is waste that has been contaminated and has the potential to endanger human health and the

environment. Hospital wastewater is not allowed to be discharged directly into rivers, lakes, or other water bodies because it will cause health problems [3]. Wastewater must be treated first to minimize the dangers of wastewater. Wastewater can cause pollution of the aquatic environment and groundwater, which then has an impact on public health [4]. This is because wastewater contains high levels of pollutants and can be harmful to human health because it contains pathogenic bacteria that cause disease [5]. Wastewater from hospital activities must be handled properly by the hospital so that it does not interfere with the hospital's function in maintaining public health [6].

Research by the University of Indonesia Research Agency in 2007 showed that 53.4% of hospitals in Indonesia carried out processing and only 51.1% carried out processing with Wastewater Treatment Plants (IPAL) and septic tanks. And only 57.5% checked the quality of IPAL effluent, and 63% of hospitals met the quality standards [1]. Law of the Republic of Indonesia Number 32 of 2009 concerning Environmental Protection and Management states that waste processing and management must be carried out for every hospital and meet quality standards in order to maintain environmental sustainability. Hospitals must be based on these regulations in order to produce good waste discharge in accordance with quality standards [7]. The suitability of treated wastewater can be seen through checking an accredited environmental laboratory for sample examination. The sample will undergo physical, chemical, and biological examinations [8].

Based on data obtained from the results of laboratory examinations in 3 months of 2023, the results showed that the physical parameters did not exceed the quality standards. Meanwhile, the BOD parameters of wastewater from PKU Muhammadiyah Hospital Surabaya exceeded the quality standards, with an average of 59 mg/L. The COD parameters are unknown due to limited laboratory equipment. Phosphate and ammonia are not yet known because laboratory checks have not been carried out. The COD, phosphate, and ammonia parameters in April, May, and June are not yet known. (Source: results of routine monthly laboratory checks by the hospital.) The results of laboratory examinations show that the BOD parameters exceed the quality standards based on East Java Governor Regulation Number 72 of 2013 concerning Wastewater Quality Standards for Industry and/or Other Business Activities, namely the BOD parameter of 30 mg/L.

RESEARCH METHOD

The study was designed using a descriptive method with the evaluation of the effectiveness of IPAL performance in the anaerobic aerobic biofitter process in reducing BOD, COD, ammonia, and phosphate levels by measuring in the laboratory. The research sample will be taken at the Inlet and Outlet of the IPAL PKU Muhammadiyah Hospital Surabaya. The samples obtained will be checked for content in the laboratory.

The population in the study was IPAL wastewater at PKU Muhammadiyah Hospital Surabaya with BOD, COD, ammonia, and phosphate parameters. Samples were taken 3 times randomly, consisting of 3 times from the inlet and 3 times from the outlet. Samples will be taken using the simple random sampling technique because the samples to be taken are homogeneous. Using the composite sampling technique with sampling at 3 different times (morning, afternoon, and evening).

The data was analyzed descriptively with a detailed description of the research results related to the research variables. Laboratory data on BOD, COD, ammonia, and phosphate levels were analyzed descriptively, referring to the quality standards of the East Java Governor Regulation Number 72 of 2013 concerning

Wastewater Quality Standards for Industry and/or Other Business Activities.

RESULT AND DISCUSSION

Laboratory Test Results

PKU Muhammadiyah Hospital Surabaya uses an anaerobic aerobic biofilter system to treat its wastewater. Wastewater from PKU Muhammadiyah Hospital Surabaya comes from the Emergency Room, General Care, Dental Room, Mother and Child Clinic, TB Clinic, Nutrition Installation, Specialist Polyclinic, Inpatient, Outpatient, Surgery, Delivery Room, ICU & NICU Services, Perinatology, Food Processing, Nutrition Installation, Differential Room, Radiology, Pharmacy Installation, Laundry, Laboratory Installation, Sanitation, and Corpse Embalming Installation.

From the results of the examination of inlet and outlet samples of the PKU Muhammadiyah Hospital Surabaya IPAL, the results were obtained as in the table below:

Table 1. Laboratory Test Results of Inlet and Outlet Samples

No	Parameter	Lab Test Results		Quality Standar	Decrease In Content	
		Inlet {1}	Outlet {2}		Mg/L P = {1}-{2}	% $\%=\frac{\{1\}-\{2\}}{\{1\}} x\ 100\%$
1.	Temperature	23,4	23	30	-	-
2.	pH	7,48	7,45	6-9	-	-
3.	BOD	62 mg/L	22 mg/L	30	40	64,51%
4.	COD	145,7 mg/L	42,75 mg/L	80	102,95	70,65 %
5.	TSS	14 mg/L	4 mg/L	30	10	71,42 %
6.	Nh3-n	2,655 mg/L	0,144 mg/L	0.1	2,511	94,57%
7.	Phospat (po4)	5,491 mg/L	3,917 mg/L	2	1,574	28,66 %

Source: Primary Data (Results of BBLKSurabaya Inspection)

Based on laboratory testing, the sample results at the inlet and outlet of the PKU Muhammadiyah Surabaya Hospital Wastewater Treatment Plant showed that the BOD and COD parameters were in accordance with the quality standard, while ammonia and phosphate did not meet the quality standard. The BOD parameter at the inlet was 62 mg/L, while at the outlet it was 22 mg/L. The COD parameter at the inlet was 145.7 mg/L, while at the outlet it was 42.75 mg/L. The inlet ammonia parameter was 2.655 ml/L, while at the outlet it was 0.144 mg/L. The inlet phosphate parameter was 5.491 mg/L, while at the outlet it was 3.917 mg/L. Based on the Regulation of the Governor of East Java Number 72 of 2013 concerning Wastewater Quality Standards for Industry and/or Other Business Activities, the permitted ammonia parameter is 0.1 mg/L and the permitted phosphate parameter is 0.2 mg/L.

Percentage of COD Reduction

From the results of the examination of the inlet BOD levels, the results obtained were 62 mg/L, and the outlet BOD results obtained were 22 mg/L. The decrease in BOD levels was 40 mg/L with a percentage decrease in BOD, that is:

Percentage decrease

$$= \frac{\text{BOD inlet} - \text{BOD outlet}}{\text{BOD inlet}} \times 100\%$$

$$= \frac{62-22}{62} \times 100\%$$

= 64,51 %

Based on the calculation results of the percentage of BOD reduction in the

wastewater treatment plant of PKU Muhammadiyah Hospital Surabaya, it was obtained as much as 64.51%. The BOD level in the outlet discharge of PKU Muhammadiyah Hospital Surabaya was 22 mg/L and in accordance with the quality standard of the East Java Governor Regulation No. 72 of 2013, which is 30 mg/L.

Percentage of COD Reduction

From the results of the examination of the inlet COD levels, the results were 145.7 mg/L and the outlet COD results were 42.75 mg/L. The reduction in COD levels was 102.95 mg/L with the percentage of COD reduction, that is:

$$\text{Percentage decrease} = \frac{\text{COD inlet} - \text{COD outlet}}{\text{COD inlet}} \text{ x } 100\%$$
$$= \frac{145,7 - 42,75}{145,7} \text{ x } 100\%$$
$$= 70,65\ \%$$

Based on the calculation results of the percentage of COD reduction in the wastewater treatment plant of PKU Muhammadiyah Hospital Surabaya, it was obtained as much as 70.65%. The COD level in the outlet discharge of PKU Muhammadiyah Hospital Surabaya was 42.75 mg/L and in accordance with the quality standard of East Java Governor Regulation No. 72 of 2013, which is 80 mg/L.

Percentage of Ammonia Reduction

From the results of the examination of inlet ammonia levels, the results were 2.655 mg/L and outlet ammonia results were 0.144 mg/L. The reduction in ammonia levels was 2.511 mg/L with the percentage of ammonia reduction, that is:

$$\text{Percentage decrease} = \frac{\text{amonia inlet} - \text{amonia outlet}}{\text{amonia inlet}} \text{ x } 100\%$$
$$= \frac{2,655 - 0,144}{2,655} \text{ x } 100\%$$
$$= 94,57\%$$

Based on the calculation results of the percentage of ammonia reduction in the wastewater treatment plant of PKU Muhammadiyah Hospital Surabaya, it was obtained as much as 94.57%. The ammonia level in the outlet wastewater of PKU Muhammadiyah Hospital Surabaya was 0.144 mg/L and did not meet the quality standards of East Java Governor Regulation No. 72 of 2013, which was 0.1 mg/L. The quality of hospital wastewater treatment plant wastewater that still exceeds the quality standards must not be discharged into water bodies.

Percentage of Phosphore Reduction

From the results of the examination of the inlet phosphate levels, the results were 5.491 mg/L and the outlet phosphate results were 3.917 mg/L. The decrease in phosphate levels was 1.574 mg/L with the percentage of phosphate reduction, that is:

$$\text{Percentage decrease} = \frac{\text{phospat inlet} - \text{phospat outlet}}{\text{phospat inlet}} \text{ x } 100\%$$
$$= \frac{5,491 - 3,917}{5,491} \text{ x } 100\%$$
$$= 28,66\ \%$$

Based on the calculation results, the percentage of phosphate reduction in the wastewater treatment plant of PKU Muhammadiyah Hospital Surabaya was 28.66%. The phosphate level in the outlet wastewater of PKU Muhammadiyah Hospital Surabaya was 3.917 mg/L and had not met the quality standards of East Java Governor Regulation No. 72 of 2013, which was 2 mg/L.

PKU Muhammadiyah Hospital Surabaya Wastewater Treatment Plant

PKU Muhammadiyah Hospital Surabaya utilizes an anaerobic aerobic biofilter system in processing its wastewater, where before treatment with a chemical biological process, pretreatment is carried out first. PKU Muhammadiyah Hospital Surabaya Wastewater Treatment Plant is equipped with 1 pretreatment tank located around the Wastewater Treatment Plant.

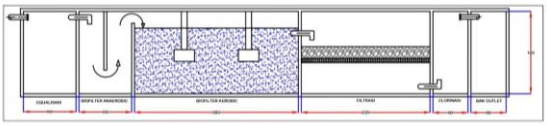

Figure 1. Wastewater Treatment Plant of PKU Muhammadiyah Hospital, Surabaya

Equalization

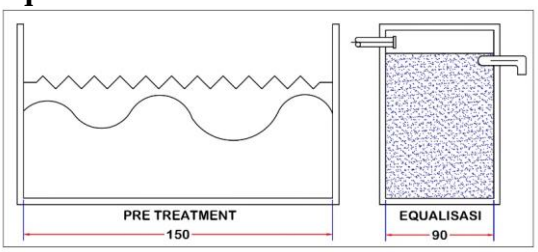

Figure 2. Pretreatment and Equalization Process

Wastewater from the inlet will be channeled to the equalization process. Equalization acts as a temporary reservoir before the water is channeled to the processing unit. The equalization tank will homogenize the wastewater and keep the discharge stable [9]. This process is an effort to avoid a (shock loading) spike in organic or hydraulic discharge. The high levels of ammonia and phosphate in the wastewater of PKU Muhammadiyah Hospital in Surabaya can be stabilized by adding decomposing bacteria to the equalization tank and identifying bacteria that are effective for seeding in the equalization tank. In the equalization tank, simple processing will be carried out to help reduce peak load fluctuations when the wastewater is processed, so that the wastewater that goes into the anaerobic process becomes stable [10]. The equalization process will increase the effectiveness of the WWTP in processing incoming waste.

Anaerobic Aerobic Biofilter

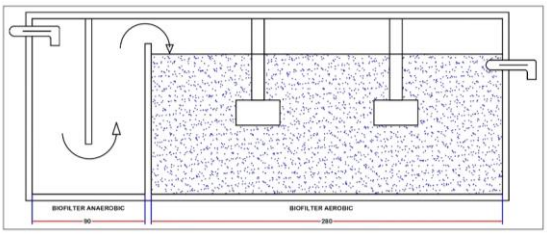

Figure 3. Aerobic Anaerobic Biofilter Process

The wastewater treatment plant system of PKU Muhammadiyah Surabaya Hospital is a combination of different anaerobic aerobic processes. The anaerobic process is a decomposition process without oxygen, while the aerobic process uses oxygen in its processing. The anaerobic aerobic process in the hospital's wastewater treatment plant acts as a reducer of COD (chemical oxygen demand), BOD (biochemical oxygen demand), ammonia, and phosphate levels in wastewater [11]. The wastewater will then go through the anaerobic process. The PKU Muhammadiyah Surabaya Hospital's wastewater treatment plant only has 1 anaerobic tank. The anaerobic process can produce methane gas (CH4) as a product of the decomposition of organic matter. Methane gas is produced as the end result of the decomposition of complex organic substances carried out by anaerobic bacteria. Methane gas is used for alternative energy to supply energy needs in the wastewater treatment plant [12]. The anaerobic process will reduce the organic load in wastewater by decomposing complex organic substances into simple substances.

The water is then discharged from the anaerobic process to the aerobic process. The aerobic tank consists of 1 tank and is not filled with media. In the aerobic tank, aeration is provided to produce oxygen for the continuation of the decomposition of organic substances by microorganisms that have not been decomposed in the anaerobic tank [10]. Microorganisms will collide with wastewater so that they will decompose phosphate (detergent) and organic substances so that nitrification can occur smoothly. The aerobic decomposition process requires oxygen for the successful decomposition of substances; the amount of oxygen must be sufficient for the decomposition needs and in line with the amount of organic substances, sulfides, and ammonia in wastewater. The number of

bacteria will accelerate the processing process for degrading pollutants in wastewater.

Wastewater treated by the anaerobic aerobic process is then pumped to the filtration section. The filtration process will separate as many suspended solids as possible by passing the waste liquid through the media or filter material. Filtration in the second stage is used to filter the effluent that has been chemically treated previously [13]. The amount of time the wastewater spends in the biofilter reactor is one factor that can affect how effective the biofilter is in reducing COD. A longer residence time is an opportunity for microorganisms to decompose pollutants in the wastewater.

Chlorination

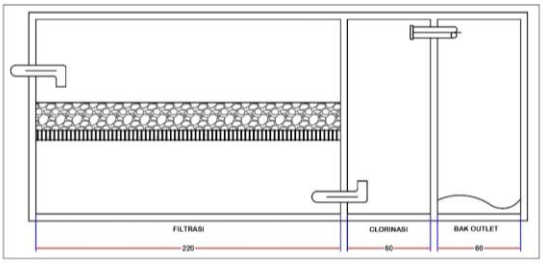

Figure 4. Chlorination process

Wastewater will then be flowed into the chlorination tank to undergo a disinfection process using chlorine. Disinfection is the cleaning of wastewater by destroying pathogenic microorganisms. The disinfection process in wastewater can be carried out using chlorine, UV, and ozone. Disinfection using chlorine as a disinfection medium can kill pathogens and help eliminate ammonia levels in wastewater [13]. PKU Muhammadiyah Hospital Surabaya uses chlorine tablets for disinfection. Chlorine tablets are placed in the pipe before the wastewater is flowed to the IPAL outlet. The combination of anaerobic and aerobic processing is effective in the process of reducing TSS, BOD, COD, ammonia, phosphate, and others [14]. With the system implemented, it is hoped that the IPAL effluent will comply with quality standards so that the wastewater from the PKU Muhammadiyah Hospital Surabaya is safe to be discharged into the drain and does not contain pathogens that cause disease.

BOD Level Reduction and Outlet Sample Analysis with Quality Standards

Based on the measurement results, the BOD level was 22 mg/L. The decrease in BOD levels after going through the processing process was 40 mg/L, with a percentage reduction in BOD levels of 64.51%. The BOD level in the outlet discharge of the PKU Muhammadiyah Hospital in Surabaya was 22 mg/L and was in accordance with the quality of the East Java Governor Regulation No. 72 of 2013, which was 30 mg/L.

Water with poor quality will contain high BOD levels. Measuring BOD parameters alone cannot indicate whether water quality contains stable or unstable organic matter. Water that is polluted by organic pollutants will be broken down in the microbiological process. The microbiological process requires dissolved oxygen during the decomposition process so that O2 in the water is reduced; this can be seen from the high and low BOD levels before and after going through the processing process [15]. Wastewater with some of the parameters that meet cannot be discharged into the sewer because it will still trigger environmental problems and disrupt the stability of the ecosystem [16].

Reduction in COD Levels and Analysis of Outlet Samples with Quality Standards

Based on the measurement results, the COD level was 42.75 mg/L. The decrease in COD levels after going through the processing process was 102.95 mg/L, with a percentage reduction in COD levels of 70.65%. The COD level in the outlet discharge of the PKU Muhammadiyah Hospital in Surabaya was 42.75 mg/L and was in accordance with the quality standards of the East Java Governor Regulation No. 72 of 2013, which was 80 mg/L.

The COD level in water indicates the total value of dissolved oxygen needed by

microorganisms in the chemical oxidation process of organic substances. Some organic substances cannot be broken down through biological processes, so they will be converted into CO2 and H2O. The decrease in COD levels that have gone through a process by microbes will illustrate the ability of microbial oxidation to decompose substances biologically with a significant decrease or no decrease [17]. Wastewater with some of the parameters that meet cannot be discharged into the sewer because it will still trigger environmental problems and disrupt ecosystem stability [16].

Ammonia Level Reduction and Outlet Sample Analysis with Quality Standards

Based on the measurement results, the Ammonia level was 0.144 mg/L. The reduction in ammonia levels after going through the processing process was 2.511 mg/L, with a percentage reduction in ammonia levels of 94.57%. The effectiveness of reducing ammonia levels in the PKU Muhammadiyah Surabaya Hospital Wastewater Treatment Plant reached > 90% but was not yet effective because it still exceeded the quality standard. The ammonia level in the outlet discharge of the PKU Muhammadiyah Surabaya Hospital was 0.144 mg/L and had not met the quality standard of the East Java Governor Regulation No. 72 of 2013, which was 0.1 mg/L.

Ammonia parameters in wastewater with high levels indicate an indication of polluted water. The aeration process that utilizes oxygen or by reacting it with hypochlorous acid (HOCl) or chlorine and converting ammonia (NH_3) into gas or chloramine or as N_2 so that it is safe for the environment [15]. Reducing ammonia levels in water can be done through a chemical process by adding several chemicals to wastewater. Chlorine (chlorine) is an additional chemical for the disinfection process in wastewater treatment. However, the use of chlorine at high levels can also be harmful to the environment because it is reactive.

Ammonia in hospital wastewater comes from food processing installations and toilets (feces and urine). Ammonia can be formed through the process of decomposing organic matter through the oxidation of organic matter caused by microbiological activities [18]. The aquatic ecosystem will be disrupted by the presence of high ammonia levels and cause toxic conditions in water bodies. The magnitude of the toxic effect of ammonia on water bodies can be controlled by pH and temperature. Ammonia reduction will occur through an aerobic process called wastewater nitrification [19]. Ammonia can cause an unpleasant odor and result in a decrease in dissolved oxygen in water bodies and can disrupt the aquatic ecosystem. Ammonia levels that still exceed the quality standards can be reduced by ensuring or adding aeration to the IPAL aeration tank [16].

Reduction of Phosphate Levels and Analysis of Outlet Samples with Quality Standards

Based on the measurement results, the phosphate content was 3.917 mg/L. The reduction in phosphate levels after going through the processing process was 1.574 mg/L, with a percentage reduction in phosphate levels of 28.66%. The phosphate level in the outlet discharge of the PKU Muhammadiyah Hospital in Surabaya was 3.917 mg/L and did not meet the quality standard of the East Java Governor Regulation No. 72 of 2013, which was 2 mg/L.

Based on research (Utami, 2018) on the reduction of phosphate in household wastewater using the phytobiofilm reactor process method, it effectively reduces up to 70%–90% of the phosphate content load of wastewater. The phyto-biofilm method is a method of utilizing aquatic plants with a combination of biofilm media that acts as a biological filter with the aim of reducing the content of pollutants in water. The use of aquatic plants (water hyacinth) combined with biofilm media, namely gravel, is one alternative phytobiofilm agent that is

effective in reducing pollutant levels in hospital wastewater.

Laundry installations and washing of cutlery are the main sources of phosphate levels in wastewater. The formation of foam from laundry and washing activities is caused by phosphate components, which will then enter the wastewater [20]. The effectiveness of reducing low phosphate levels can be caused by waste from laundry and bathrooms not being treated first before entering the IPAL tank. High phosphate levels can also be due to the provision of decomposing bacteria in insufficient quantities. The waste load with the number of decomposing bacteria will affect the quality of the IPAL flowers. Therefore, before laundry and bathroom waste is flowed into the IPAL, the hospital should carry out pre-treatment first to reduce the phosphate load, and the number of decomposing bacteria in the equalization tank can be calculated or added. The choice of the type of cleaning agent content also needs to be considered so that it can help reduce the burden of phosphate levels produced [19].

CONCLUSION AND RECOMMENDATION

The BOD and COD parameters are in accordance with the quality standard, while ammonia and phosphate do not meet the quality standard according to the Regulation of the Governor of East Java Number 72 of 2013. The BOD level is 22 mg/L, which means it has met the quality standard of 30 mg/L, while the COD is 42.75 mg/L, which means it has met the quality standard of 80 mg/L. The ammonia level is 0.144 mg/L, which means it does not meet the quality standard of 0.1 mg/L. The phosphate level is 3.917 mg/L, which means it does not meet the quality standard of 0.2 mg/L.

The decrease in BOD levels after going through the processing process is 40 mg/L, and COD is 102.95 mg/L. The percentage of effectiveness of reducing BOD is 64.51%, and COD is 70.65%. The wastewater treatment plant at PKU Muhammadiyah Hospital Surabaya has been effective in reducing BOD and COD levels in its wastewater discharge because it does not exceed the standard quality of East Java Governor Regulation No. 72 of 2013. The decrease in ammonia levels after going through the treatment process was 2.511 mg/L, and phosphate levels were 1.574 mg/L. The percentage of effectiveness in reducing ammonia levels was 94.57% and phosphate levels was 28.66%. The wastewater treatment plant at PKU Muhammadiyah Hospital Surabaya has not been effective in reducing ammonia and phosphate levels in its wastewater discharge because it still exceeds the standard quality of East Java Governor Regulation No. 72 of 2013.

Conduct monitoring and evaluation of the anaerobic aerobic biofilter and evaluate the quality of the liquid waste outlet every month, especially the ammonia and phosphate parameters. Identify effective bacteria for seeding in the equalization tank so that the outlet discharge is in accordance with the standard quality.

REFERENCES

[1] B. Rahmat and A. Mallongi, "Studi Karakteristik dan Kualitas BOD dan COD Limbah Cair Rumah Sakit Umum Daerah Lanto DG. Pasewang Kabupaten Jeneponto," *J. Nas. Ilmu Kesehat.*, vol. 1, no. 69, pp. 1–16, 2018.

[2] P. Goni, I. R. Mangangka, and O. B. A. Sompie, "Evaluasi Kinerja Instalasi Pengolahan Air Limbah (IPAL) Rumah Sakit Umum Pusat Prof. Dr. RD Kandou Manado," *TEKNO*, 2021. https://ejournal.unsrat.ac.id/index.php/tekno/article/view/33209

[3] L. Rawis, I. R. Mangangka, and R. R. I. Legrans, "Analisis Kinerja Instalansi Pengolahan Air Limbah (IPAL) di Rumah Sakit Bhayangkara Tingkat III Manado," *Tekno*, vol. 20,

no. 81, 2022.

[4] M. K. Baeti, M. Raharjo, N. A. Y. Dewanti, and S. Sulistiyani, "Efektivitas Instalasi Pengolahan Air Limbah (IPAL) Rumah Sakit Umum Roemani Muhammadiyah Semarang," *J. Kesehat. Masy.*, vol. 10, no. 3, pp. 281–289, 2022.

[5] A. B. Birawida, "Uji Efektifitas Kualitas Ipal Menggunakan Bio-Media Di Rumah Sakit Daerah Hikmah Masamba," *Jurnal Nasional Ilmu Kesehatan (JNIK)*. 2019.

[6] B. C. Kasih, S. Romadon, and "Analisis Evaluasi Kinerja Dan Proses Instalasi Pengolahan Air Limbah (IPAL) Rumah Sakit," *Eng. J. ITATS*, 2023. http://ejurnal.itats.ac.id/envitats/article/view/05

[7] N. T. Dewi, G. D. Wibowo, P. S. Pudyastuti, and "Evaluasi dan Perancangan Ulang Desain Instalasi Pengolahan Air Limbah (IPAL) di Rumah Sakit PKU Muhammadiyah Yogyakarta,"*Din.Tek.Sipil*2023.https://journals.ums.ac.id/index.php/DTS/article/view/23275

[8] S. Apip, Analisis Efektivitas Instalasi Pengolahan Air Limbah (IPAL) Di Rumah Sakit Umum Daerah Kabupaten Sumedang Dengan Parameter BOD. 2021. http://repo.usni.ac.id/id/eprint/2683

[9] K. J. Harum, Manajemen Pengelolaan Air Limbah di Rumah Sakit. 2022. https://repository.stikes-yrsds.ac.id/id/eprint/435/

[10] S. Purwanto, "Sistem Instalasi Pengolahan Air Limbah (IPAL) Pada Rumah Sakit Umum Daerah (RSUD) Selasih Kabupaten Pelalawan." Universitas Islam Riau, 2019.

[11] M. R. Ramadan, "Perencanaan Pengembangan desain Instalasipengolahan Air Limbah (IPAL) di Rumah Sakit Urip Sumoharjo Kota Bandar Lampung Tahun 2021." Poltekkes Tanjungkarang, 2021.

[12] N. N. U. R. FADILLAH, "Arang Aktif Dari Kulit Singkong Sebagai Adsorben Dalam Penurunan Kadar COD dan TSS Limbah Cair Tepung Tapioka." Universitas Muhammadiyah Purwokerto, 2021.

[13] H. Kandida, "Manajemen Pengelolaan Air Limbah di Rumah Sakit," Undergrad. Thesis, STIKES Yayasan RS Dr. Soetomo Surabaya, pp. 4–16, 2023.

[14] J. T. Lingkungan, "Air Limbah dan Sistem Daur Ulang," 2017.

[15] R. O. Pratiwi, "Studi Karakteristik Limbah Cair dari Kegiatan Penyamakan Kulit di Bantul, D.I Yogyakarta," pp. 1–64, 2019.

[16] L. Rawis, I. R. Mangangka, and R. R. I. Legrans, "Analisis Kinerja Instalansi Pengolahan Air Limbah (IPAL) di Rumah Sakit Bhayangkara Tingkat III Manado," *TEKNO*, 2022, https://ejournal.unsrat.ac.id/index.php/tekno/article/view/42567

[17] M. S. Alim and R. Noor, "Efisiensi Kinerja Instalasi Pengolahan Air Limbah Dengan Sistem Conventional Activated Sludge Termodifikasi Attached Growth Media Di Ipal Rsud Ulin Efisiensi Kinerja Instalasi Pengolahan Air Limbah (IPAL) Dengan Sistem Conventional Activated Sludge Termod," *Barometer*, vol. 7, no. 1, pp. 44–52, 2022. http://www.journal.unsika.ac.id

[18] R. U. Br Tarigan, "Kemampuan Acinetobacter Baumannii dan Nitrobacter Winogradskyi Dalam Menurunkan Kandungan Fosfat dan Amonia Limbah Cair Rumah Sakit." Universitas Atma Jaya Yogyakarta, 2019.

[19] P. Pitriani *et al.*, "Efektivitas Biofilter Dalam Mereduksi Polutan Pada Air Limbah Rumah Sakit Di Kota Palu," *Afiasi J. Kesehat. Masy.*, vol. 7, no. 1, pp. 245–253, 2022, doi: 10.31943/afiasi.v7i1.196.

[20] A. R. Utami, "Penurunan Kadar Fosfat Dalam Limbah Rumah Sakit Dengan Menggunakan Reaktor Fitobiofilm," *J. Teknol. Proses dan Inov. Ind.*, vol. 3, no. 1, 2018, doi: 10.36048/jtpii.v3i1.4185.